University of Maine.

Maine Agricultural Experiment Station

ORONO

BULLETIN 223 JANUARY 1914

SPRAYING EXPERIMENTS AND APPLE DISEASES IN 1913.

CONTENTS.

MAINE
AGRICULTURAL EXPERIMENT STATION
ORONO, MAINE.

THE STATION COUNCIL.

PRESIDENT ROBERT J. ALEY,	*President*
DIRECTOR CHARLES D. WOODS,	*Secretary*
CHARLES L. JONES, Corinna,	*Committee of Board of Trustees*
FREELAND JONES, Bangor,	*Committee of Board of Trustees*
WILLIAM A. MARTIN, Houlton,	*Committee of Board of Trustees*
JOHN A. ROBERTS, Norway,	*Commissioner of Agriculture*
EUGENE H. LIBBY, Auburn,	*State Grange*
HOWARD L. KEYSER, Greene,	*State Pomological Society*
RUTILLUS ALDEN, Winthrop,	*State Dairymen's Association*
LEONARD C. HOLSTON, Cornish,	*Maine Livestock Breeders' Association*
WILLIAM G. HUNTON, Readfield,	*Maine Seed Improvement Association*

And the Heads and Associates of Station Departments, and the Dean of the College of Agriculture.

THE STATION STAFF.

ADMINISTRATION.	CHARLES D. WOODS, Sc. D.,	*Director*
	BLANCHE F. POOLER,	*Clerk*
	GEM M. COOMBS,	*Stenographer*
	JANIE L. FAYLE,	*Stenographer*
BIOLOGY	RAYMOND PEARL, Ph. D.,	*Biologist*
	FRANK M. SURFACE, Ph. D.,	*Biologist*
	MAYNIE R. CURTIS, Ph. D.,	*Assistant*
	CLARENCE W. BARBER, B. S.,	*Assistant*
	JOHN RICE MINER, B. A.,	*Computer*
	HAZEL F. MARINER, B. A.,	*Clerk*
	FRANK TENNEY,	*Poultryman*
CHEMISTRY	JAMES M. BARTLETT, M. S.,	*Chemist*
	HERMAN H. HANSON, M. S.,	*Associate*
	EDWARD E. SAWYER, B. S.,	*Assistant*
	ELMER R. TOBEY B. S.,	*Assistant*
	HAROLD P. VANNAH, B. A.	*Assistant*
	HARRY C. ALEXANDER,	*Laboratory Assistant*
ENTOMOLOGY	EDITH M. PATCH, Ph. D.,	*Entomologist*
	ALICE W. AVERILL,	*Laboratory Assistant*
PLANT PATHOLOGY	WARNER J. MORSE, Ph. D.,	*Pathologist*
	MICHAEL SHAPOVALOV, M. S.,	*Assistant*
	VERNON FOLSOM,	*Laboratory Assistant*
HIGHMOOR FARM	WELLINGTON SINCLAIR,	*Superintendent*
	HAROLD G. GULLIVER,	*Scientific Aid*
ROYDEN L. HAMMOND,		*Seed Analyst and Photographer*
CHARLES S. INMAN,		*Assistant*

BULLETIN No. 223.

SPRAYING EXPERIMENTS AND STUDIES ON CERTAIN APPLE DISEASES IN 1913.

W. J. Morse.

In spite of the fact that a large amount of work has been done both in this and in other countries, in studying the effects of different insecticides and fungicides upon the trees themselves and their efficiency in controlling the various insect and fungous pests, the ideal spray or combination of sprays for use on apple orchards has not yet been discovered. It is true that with the introduction of lime-sulphur some of the previous difficulties have been eliminated, but at the same time there are others of equal importance which have arisen or which have not been overcome. This is particularly the case under the climatic conditions which exist in the apple growing regions of the northeastern portion of the United States and the adjacent parts of the Dominion of Canada where apple scab frequently appears in its most virulent form.

While it is granted that lime-sulphur, as ordinarily used, has been found to be less likely to produce spray injury many orchardists maintain that in practical work it is less efficient with them than bordeaux mixture in controlling apple scab. In fact a prominent apple grower from the famous Annapolis valley of Nova Scotia recently told the writer that even with the most careful and thorough spraying with lime-sulphur their fruit the past season was badly attacked by scab and that many orchardists were seriously considering going back to bordeaux mixture again next year. On the other hand it has been the writer's experience that with varieties susceptible to spray injury lime-sulphur is, on the whole, by far the most satisfactory material.

As a rule we have found that with the Ben Davis spray injury from bordeaux mixture was so severe that it equalled or more than offset the beneficial effects derived from the control of apple scab. While a much better grade of fruit from the standpoint of keeping quality and freedom from disease has been the invariable result from trees sprayed with this material the russeted appearance of the skin materially reduced its market value. In other words, while the injurious effects of bordeaux mixture and certain other sprays upon the fruit of susceptible varieties like the Ben Davis are concerned almost wholly with the appearance of the fruit and not with its keeping quality or value as an article of food, the price it will bring on the market is just as effectually reduced as though the latter were the case. If the selling price of apples depended more on the quality of the fruit and less on the appearance of the skin certain of the difficulties now experienced in spraying would disappear.

The difficulties encountered in spraying apple orchards are not restricted to spray injury of the fruit however. It is a well known fact that the leaves of certain varieties are frequently injured by sprays and that the occurrence and severity of this injury is markedly influenced by seasonal climatic conditions in the case of bordeaux mixture. During the 5 seasons that this Station has experimented with this spray on Baldwin and Ben Davis trees at Highmoor Farm leaf injury has been experienced in some degree each year, and some years it has been so severe as to result in a decided leaf drop in mid-summer. For the main orchards, consisting of some 2300 trees it became necessary to abandon its use altogether.

The question of the proper fungicide to use is by no means the only important matter involved in efficient orchard spraying. Insecticides are necessary and it is both necessary and convenient to use them in combination with fungicides. New forms of both of these are constantly being recommended and the orchardist is urged by manufacturers of various proprietary compounds to substitute these for the materials already in use, on the ground of their greater efficiency, economy, or ease of use. Often these are placed on the market without being sufficiently tested by their makers, under a variety of conditions, to determine their effects on the foliage and fruit in combina-

tions with materials which must be used with them and disastrous results are secured in the hands of the purchasers.

While a fairly settled policy has been reached as to the proper time to apply the various sprays or combinations of sprays to secure the greatest efficiency there is still insufficient data with regard to some of these points, particularly as applied to local conditions.

The present publication constitutes the fourth report of the results of a series of orchard spraying experiments designed to secure additional data upon some of the points mentioned above.* It has also seemed desirable to include in the same bulletin certain observations which have been made during the year upon apple scab and apple cankers.

Spraying Experiments in 1913.

During the past season the spraying experiments were conducted in the same portion of one of the orchards as in previous years but included 238 instead of 139 trees used in 1912, or 40 rows of 6 trees to the row, with one tree missing in each of two rows. The plots were changed somewhat to avoid a supposed difficulty of the previous year. While, as will be seen later, the results of the present year indicate that this idea was incorrect it was thought that the relatively small amount of scab appearing in 1912 on the plot sprayed only with 4 pounds of arsenate of lead paste in 50 gallons of water might be partially due to its location at the corner of the orchard and thus better exposed to sunlight and drying winds.

The trees were of the Ben Davis variety and are between 25 and 30 years old. They are now in a very healthy, vigorous condition. For the last 4 years they have been well cultivated, fertilized and pruned. In 1909 some renovation work was done on them but previous to this they had been badly neglected for several years.

The 1913 experiments comprised 10 different plots. All plots used for making important comparisons between fungicides, except that sprayed with bordeaux mixture, consisted of

* The previous reports are given in Bulletins 189, 198 and 212 of this Station. The first two are now out of print and are no longer available for distribution.

6 rows each, or 36 trees. The unsprayed check, the bordeaux plot, the arsenite of zinc plot and those upon which insecticides were used alone consisted of 3 rows each, or 18 trees.

All plots received the same number of sprayings on the same dates with the exception of plot 4. On this the first application of lime-sulphur was omitted for comparison with plot 3 to test the efficiency in control of apple scab of the application usually made when the blossom buds are showing pink. All spray materials were applied with a gasoline power spraying outfit at a pressure of from 125 to 150 pounds. The tank, pump and hose were thoroughly washed out with water after each separate spray material was used. The original plan was to spray all plots with the exception of number 4 when the blossom buds were showing pink, repeat the application for all, number 4 included, just after the petals fell and again about 2 weeks later. This program was adhered to except that between the second and third sprayings a period of 21 days elapsed.

Weather conditions during the early part of the season materially influenced the date of application of the different sprays. The latter part of April and the first week of May were abnormally warm and very little rain fell. As a result the blossom buds came along very rapidly so that they were in condition such that it was necessary to make the first application on May 8. This was immediately followed by a month of unseasonably cold weather with frosts and cold, northwest winds associated with continued cloudy weather and heavy rainfall. The flower buds opened very slowly and the petals did not drop so that the second application could be made till June 3. This allowed an interval of 26 days between the first and second applications as compared with only 12 in 1912. The third and last application was made on June 24.

In 1913 dry, powdered arsenate of lead, using half the quantity by weight as compared with the paste form previously employed, was adopted for use on all the orchards on the farm. On all the experimental plots sprayed with a fungicide, (not counting plot 10 where arsenite of zinc was used) one pound of this dry arsenate of lead was added as an insecticide to each 50 gallons of spray. With this exception the treatment of each plot is given below.

Plot 1 18 trees, bordeaux mixture, 3-3-50 formula.
Plot 2 35 trees, lime-sulphur, 20 per cent stronger than standard dilution.
Plot 3 36 trees, lime-sulphur, standard dilution (1.5 gals. 29° Baumé, home-cooked concentrate diluted to 50 gals.)
Plot 4 35 trees, lime-sluphur, standard dilution, first application omitted.
Plot 5 36 trees, "Soluble sulphur," 2 pounds to 50 gallons of water.*
Plot 6 36 trees, "Atomic sulphur," 7 pounds to 50 gallons of water.*
Plot 7 18 trees, unsprayed check.
Plot 8 18 trees, 1 pound of dry arsenate of lead in 50 gallons of water.
Plot 9 18 trees, 2 pounds of dry arsenate of lead in 50 gallons of water.
Plot 10 18 trees, standard dilution lime-sulphur plus 1 pound of arsenite of zinc to 50 gallons.

The orchards bloomed profusely and at the time of the first spraying there was promise of a full crop of fruit. Mention has been made of the weather conditions which prevailed during the first part of the season. Between May 8 and the close of the month somewhat over 4 inches of rain fell, many of the days were cloudy and cold with prevailing northwest winds. Freezing temperatures were recorded on May 14, 15 and 21. This resulted in very imperfect pollination and apparently many

* The Soluble sulphur and Atomic sulphur are proprietary spray materials and were supplied by the manufacturers, the Niagara Sprayer Company Middleport, New York, and the Thomsen Chemical Company, Baltimore, Maryland. The former in the literature sent out last spring recommended that their soluble sulphur compound be used for spraying trees in foliage at the rate of 1½ to 2 pounds to each 50 gallons of water. Mr. W. M. Scott, pathologist for the Thomsen Chemical Company in correspondence stated that Atomic sulphur should be used at the rate of 7 pounds to 50 gallons of water but that a greater quantity would do no harm. His letter and supply of material did not arrive till after the date of the first application. Hence it was necessary to purchase a supply from their State agency which recommended that Atomic sulphur be used at the rate of 14 pounds to 50 gallons. This was done at the first spraying but 7 pounds were used in the last two.

of the partially opened buds were killed by frost. On June 2 considerable frost injury was noted on the young leaves throughout the orchards. By June 10 it was evident that a large proportion of the flowers had failed to set fruit and were falling off. As a result the crop obtained was only about 10 per cent of that harvested in 1912.

EFFECT OF DIFFERENT SPRAYS ON THE FOLIAGE.

On June 2 there was some evidence of spray injury on plot 1, sprayed with bordeaux mixture, but the leaves on the other plots were entirely healthy with the exception of the frost injury mentioned above. A small amount of spray injury developed on plot 1 during the season but at no time was it sufficient to do any appreciable damage or to cause any material amount of leaf drop—a marked contrast with the results obtained in some of the previous experiments where bordeaux mixture was applied. The control of scab on the leaves was almost perfect and better on this plot than on any of the others.

Plot 2, sprayed with lime-sulphur 20 per cent stronger than standard dilution, showed some leaf injury from the spray but this was very slight and somewhat less than was observed on plot 1. In this case, however, the injury did not appear until after the second application of the spray. Scab control on the leaves while not equalling that where bordeaux mixture was used, was better than that on all of the remaining plots.

Plot 3, where standard dilution lime-sulphur was applied, was practically free from leaf injury throughout the season, although a little was noted. Scab on the leaves was fairly well controlled, but more in amount than on plot 2. This began to appear about June 10 or later.

Plot 4, treated the same as plot 3 except that the first application of lime-sulphur when the flower buds were showing pink was omitted, agreed in appearance with plot 3 throughout the season as far as the condition of the foliage was concerned. The control of scab seemed to be as good in one case as in the other.

Plot 5, where "Soluble sulphur" was applied, presented a marked contrast with the other plots where fungicides were

used. Up to June 3 no difference could be observed between the foliage on the trees on this plot and that on those which had been sprayed with lime-sulphur, but shortly after the second application of the spray very evident injury began to appear.

This injury was in the form of spotting and more or less browning of the margins of the leaves and continued to develop slowly till the time of the third application on June 24. After the third application this spray injury developed very rapidly and became quite severe. On July 7, 75 to 90 per cent of the leaves on all of the trees on this plot were spotted or burned at the margins, or both, many of them being badly injured. Much yellowing and leaf drop showed at this time. The specimens shown in Fig. 1 were collected on this date. The yellowing and falling of the leaves continued for over a month afterwards and conditions on July 15 were recorded as worse than on July 7, the ground being nearly covered with fallen leaves at this time. As a result of this leaf fall the "Soluble sulphur" plot presented a marked contrast to the other fungicide plots when viewed at a distance. It could be located readily on account of the sparse condition of the foliage.

"Soluble sulphur" appeared to be fully equal to standard dilution lime-sulphur in controlling scab on the leaves.

Plot 6, sprayed with "Atomic sulphur" showed nothing on the foliage throughout the season which could be definitely classed as spray injury, although an occasional brown spot was observed on the leaves. With regard to scab control it equalled or exceeded all others except the bordeaux plot.

Plot 7, unsprayed check. Scab on this, like the sprayed plots, did not appear on the leaves till about June 10, or midway between the dates of the second and third applications, but from then on it developed very rapidly on both foliage and fruit. It was recorded as very common and severe, especially on some trees, on July 7 and 15, and nearly every leaf was reported as affected on August 4. Nothing like what has been classed as spray injury on the other plots was observed on the check, but frost injury was noted on this as well as on the others early in the season.

Plot 8, sprayed with one pound of dry arsenate of lead in 50 gallons of water. Throughout the season it was plainly

evident that the amount of scab on the leaves of the trees on this plot was considerably less than on the unsprayed check but it was also equally apparent that it was more than on the adjoining plot, sprayed with the larger amount of arsenate of lead, and more than on the plots sprayed with fungicides plus the same amount of arsenate as was used on it.

The only evidence of spray injury observed was a slight spotting of the leaves and this in all cases appeared to be associated with areas of leaf surface where the epidermis had first been attacked by the scab fungus, allowing the poison to come in contact with the interior tissues.

On plot 9, sprayed with 2 pounds of dry arsenate of lead in 50 gallons of water, the control of scab on the leaves throughout the season appeared to be fully equal to that where standard dilution lime-sulphur and the smaller quantity of arsenate had been used together.

Some spotting of the leaves was observed similar to that described on plot 8, but up to the middle of August this was of no consequence. After this date the farm was visited less frequently and less detailed records were kept as to the condition of the foliage. At harvest time it was discovered that more or less spotting of the leaves had developed late in the season and that there had been a slight amount of premature leaf fall. However it may be said that the general health of the foliage on the trees on this plot throughout the season as a whole compared favorably with that on the lime-sulphur plots.

Plot 10, standard dilution lime-sulphur plus one pound of arsenite of zinc to 50 gallons. This plot was introduced simply to secure additional data as to the combined effect of arsenite of zinc and lime-sulphur on apple foliage. In 1912 this combination gave no appreciable spray injury but in 1913, used in exactly the same manner, in the same proportions, and from the same stock of arsenite of zinc a decidedly opposite result was obtained. This year severe leaf injury resulted. The character, amount and time of appearance of this was almost identical with that produced by "Soluble sulphur" already described. The specimens shown in Fig. 2 were collected on July 7.

EFFECT OF DIFFERENT SPRAYS ON THE FRUIT.

Detailed records were kept throughout the season of the appearance of the fruit with reference to scab and russeting but they tell little which is not also given in the tabulated results of the condition of the fruit at harvest time. The first record of the beginning of russeting of the fruit was on July 7 but the experiment was not visited by the writer between June 24 and this date. It is interesting to note that at this time russeting was recorded on all of the plots, including the unsprayed check.

The crop was harvested on October 5 and sorted immediately thereafter. In 1912 about 20 barrels of apples from the rows near the center of each plot were set aside for careful sorting and record as to the condition of the fruit. In 1913, on account of the short and irregular crop on the trees, all of the apples on each plot were saved for sorting and counting except those borne on the half of each outside row which adjoined another plot having a different treatment. While this may not have entirely eliminated the effects of the spray drifting from one plot to another it was felt that it did so in a large measure.

The following is a tabulated summary of the results obtained from sorting and counting the number of fruits on each of the different plots. The percentages of smooth, scabby and russeted fruit do not always total 100 for in some instances apples were found which were both scabby and russeted and were counted twice. All apples which showed any traces of scab were classed as scabby. None were classed as russeted unless this was plainly evident. That is, apples which showed minor scars or imperfections of the skin were classed as smooth.

Summary of Results Obtained from Sorting Fruits.

Plot No.	Treatment.	Total number of apples.	Number smooth.	Number scabby.	Number russeted.	Per cent of perfect apples.	Per cent of scabby apples.	Per cent of russeted apples.	Difference in per cent of russeting as compared with check.
1	Bordeaux mixture 3-3-50	1,400	416	11	973	29.7	0.8	69.5	37.9
2	Lime-suplhur 20% stronger than standard	4,102	2,449	46	1,625	59.7	1.12	39.6	8
3	Lime-sulphur standard dilution (1.5 gals. 29° Baumé, diluted to 50 gals)	3,421	1,886	108	1,446	55.1	3.15	42.2	10.6
4	Lime-sulphur standard dilution, first application omitted	2,056	1,054	131	871	51.2	6.32	42.3	10 7
5	"Soluble sulphur" 2 pounds to 50 gals. of water	1,885	974	68	843	52.7	3.6	44.7	13.1
6	"Atomic sulphur" 7 pounds to 50 gals. of water	3,032	1,674	95	1,263	55.2	3.13	41.6	10
7	Unsprayed check	1,693	501	657	535	29.5	38.8	31.6	-
8	One pound of dry arsenate of lead in 50 gals. of water	2,311	1,183	362	766	51.1	15.6	33.1	1.5
9	Two pounds of dry arsenate of lead in 50 gals. of water	1,416	954	39	423	67.3	2.75	29.8	-1.8
10	Standard dilution lime-sulphur plus 1 pound arsenite of zinc to 50 gals.	1,961	1,067	217	677	54.4	11	34.5	2.9

DISCUSSION OF RESULTS.

The experiments of the present year were designed, in a measure, to supplement the data obtained in 1912, hence in the discussion of the results obtained this year it is necessary to take into consideration certain of those obtained last year and reported in Bulletin 212.

Efficiency of the first spray application. It is claimed by some that the spray application made when the buds are showing pink is the most effective one in controlling apple scab. That this may be the case was shown in a most striking manner in 1912. Where this spray (lime-sulphur) was omitted only about 50 per cent of perfect apples were obtained and over 47 per cent were scabby. Where it was applied nearly 90 per cent of the fruit was sound and perfect and less than 1.5 per cent were scabby. The general conclusion was that, under the climatic conditions which prevailed that season, the two later sprayings paid little more than the cost of application. Attention was called to the fact that while this is important as showing the value of the first spraying it should not be taken as implying that the two later sprayings should be omitted.

The results secured in this part of the 1913 experiment would seem quite contradictory to those obtained the previous year. It will be noted on reference to the table that while the figures favor the plot where all three applications were made these differences are probably within the limits of experimental error. Plot 4 produced only about 4 per cent less perfect apples and 3 per cent more scab than plot 3.

It is difficult to account for this failure of the omission of the first application of the spray to show greater differences in the line of scab control. Had there been an excessive amount of scab on both plots with only this amount of difference it would be fair to assume that the period which elapsed between May 8 and the time of the second spraying allowed the disease to become established. As a matter of fact when compared with plot 7, or the unsprayed check which gave nearly 40 per cent of scabby apples, it will be seen that scab control was quite efficient even in the case of plot 4. An explanation of the results which seems very probable is that while the warm period the latter part of April and the first of May was sufficient to

start the flower buds it was not sufficiently prolonged to cause the liberation of the spores of the perfect stage of the fungus, which form on the fallen leaves of the season before and which are generally conceded to be the chief source of early spring infection. With the very cold period following it may be that these spores were not in a condition to be thrown off till about or shortly before the second spraying. None of the limb infection by scab like that described later in this bulletin was observed in the experimental orchard.

Dilution of lime-sulphur. In 1912 the results suggested that a dilution of lime-sulphur 20 per cent stronger than the standard could be used on Ben Davis trees with little more danger of injuring the leaves or russeting the fruit and that the increased efficiency of the spray would more than pay the added cost, particularly where the lime-sulphur concentrate is prepared at home. The results in 1913 have strengthened this position rather than weakened it. While the differences were not so marked as last season when the stronger solution produced about 23 per cent less scabby apples than the standard dilution it will be seen on comparing plots 2 and 3 that the per cent of perfect apples was greater, and the efficiency in scab control in the case of the stronger solution was almost equal to that of bordeaux mixture.

Lime-sulphur vs. bordeaux mixture. The continued use in this series of experiments of a plot sprayed with bordeaux mixture is solely for the purpose of comparison. The efficiency of bordeaux mixture in controlling apple scab and the almost certain occurrence of foliage injury and fruit russeting from its use on the variety of apples employed in the experiments are well established facts. Such a plot in conjunction with an unsprayed check is of value as a standard by which to judge the action of the other fungicides in controlling scab or in the production of spray injury. In 1912 bordeaux mixture produced a greater percentage of perfect apples than did standard dilution lime-sulphur, but the stronger lime-sulphur produced better results than either of these. In 1913 almost perfect control of scab on the fruit was obtained from bordeaux mixture but on account of russeting less than 30 per cent of perfect apples were obtained. On the other hand very efficient control

of scab was secured with lime-sulphur, particularly the stronger dilution, and the percentage of perfect apples was about double that secured with bordeaux mixture. Hence the results secured during the last season are very much in favor of lime-sulphur.

"Soluble sulphur." Judging from the results of a single season alone it would seem that this compound is a fairly efficient fungicide as far as apple scab is concerned and fully equal in this respect to the standard dilution lime-sulphur as will be seen in comparing the results secured on plots 3 and 5. Unfortunately, as has already been pointed out on page 7, its use at the rate of 2 pounds to 50 gallons of water produced very severe leaf injury. Based on our own experience and that of others during the past summer, which latter is given under another heading, "Soluble sulphur," used with arsenate of lead at this strength at least, cannot be recommended as a safe summer spray for apple trees.

"Atomic sulphur." The results secured with this material were very satisfactory. No spray injury was observed on the leaves and it will be seen on comparing plots 3 and 6 that the condition of the fruit harvested from the plot sprayed with "Atomic sulphur" was practically identical with that from the standard dilution lime-sulphur plot. While these results were in every way satisfactory one is not warranted drawing final conclusions without farther comparative tests. It is admitted that the relatively efficient scab control with this material may be partly due to using it, through error, at double strength for the first application, but attention is called to the fact already pointed out that omitting an application of lime sulphur at this time produced practically no difference in the results.

Arsenate of lead as a fungicide. In the above discussion relative to the control of scab on the different plots the action of arsenate of lead, which is added as an insecticide, has been ignored as a factor in producing the effects obtained. Moreover, this appears to be the customary attitude in dealing with experiments of this nature. The results secured on plots sprayed with different amounts of arsenate of lead alone, during the past two seasons, suggest that this is an erroneous position to take. Not only that but one is strongly tempted to go one step farther and say that there is reason to believe that so

far as scab is concerned the fungicides commonly employed in spraying apple trees, when used with arsenate of lead, have been receiving in some instances much more credit than they really deserve.

However it should be mentioned that this is by no means the first time that the fungicidal effect of arsenate of lead has been observed. Waite* called attention to the fact in 1910, but stated that while this insecticide when used alone possessed considerable fungicidal value it was probably not enough to be depended upon for general use. In his experiments, however, only 2 pounds of paste were used to 50 gallons of water. Wallace, Blodgett and Hessler† in both field and laboratory tests also showed that the addition of arsenate of lead to lime-sulphur solution increased the fungicidal value of the spray. Taylor‡ secured somewhat similar results in Missouri in the control of peach scab and brown rot but in the case of the latter disease it was thought that the effects were indirect and were the result of control of the curculio which punctures the skin and thus assists the fungus in gaining entrance to the fruit.

In our own experiments plots were sprayed with 2 and 4 pounds of arsenate of lead paste in 50 gallons of water in 1912. In 1913 the powdered form of the insecticide was substituted, this being used at the rate of 1 and 2 pounds in 50 gallons of water. The 1912 experiment was begun in the writer's absence and, unfortunately, no unsprayed check was saved. However the results obtained were quite striking. Where the larger amount of arsenate of lead paste was used alone scab was controlled as well as on any plot sprayed with the recognized fungicides, exceeding that obtained with bordeaux mixture and standard dilution lime-sulphur and only being equalled by the stronger lime-sulphur.

With the above results in mind the figures obtained in 1913 possess added significance. Where the 2 pounds of dry arsenate

---

* Waite, M. B., Experiments on the Apple with Some New or Little-Known Fungicides Cir. U. S. D. A. Bur. Pl. Ind. 58, 1910.

† Wallace, E., Blodgett, F. M. and Hessler, L. R. Studies of the Fungicidal Value of Lime-Sulphur. Bul. Cornell Agr. Exp. Sta. 290, 1911.

‡ Taylor, E. P., Spraying Peaches for Brown Rot, Western Fruit Grower, pp. 20-21, Oct. 1909, pp. 16-18, Feb. 1910.

of lead were used alone in 50 gallons of water scab was better controlled than on all other plots except those where bordeaux mixture and the stronger lime-sulphur were applied. Moreover, it will be seen on reference to the table that a greater percentage of perfect apples was obtained from this plot than from any other in the series. That even small or medium applications of arsenate of lead possess a distinct fungicidal value is readily seen by comparing the check plot, number 7, with plot 8 adjoining it where one pound of the powdered form was used in 50 gallons of water. Here the amount of scab was reduced from nearly 39 to less than 16 per cent and the percentage of perfect apples obtained compared very favorably with those plots on which fungicides had been used in addition to the same amount of powdered arsenate of lead as was used on plot 8.

While the writer is not ready as yet, without repeated experimental tests, to recommend so radical a departure as placing entire dependence upon arsenate of lead alone for the control of scab and insect enemies in apple orchards in Maine the results so far obtained are certainly encouraging. It is not beyond the range of probability that efficient scab control with a minimum of fruit russeting might be obtained by using a dormant spray of strong lime-sulphur or bordeaux mixture before the leaf-buds open and then for later applications nothing but from 1 1-2 to 2 pounds of powdered or from 3 to 4 pounds of the paste form of arsenate of lead in 50 gallons of water. Since practically all the foliage and fruit injury from bordeaux mixture comes from the later applications still greater efficiency in scab control might be obtained with no added danger from russeting and leaf spotting if this is used when the flower buds are showing pink. Such a procedure would entirely eliminate lime-sulphur except as a dormant spray where its use is absolutely required in many orchards on account of the blister mite and other insects.

Objection to this use of still greater quantities of arsenate of lead might be raised on account of the claim made by some that the accumulation of arsenic in the soil from its continued use as a spray material tends to produce detrimental effects on the trees themselves. Headden has shown this to be the case in

Colorado, but here the results are brought about through the action of the alkali in the soil or irrigation water converting the insoluble lead arsenate into soluble compounds.* So far as the writer has been able to learn no evidence of similar action has been observed in the East. As a matter of fact the amounts of lead arsenate advocated for use alone are not materially greater than now used in combination with fungicides like lime-sulphur.

Russeting of fruit. One fact has been strikingly brought out in the experiments conducted during the past season which has been evident to a greater or less degree during preceding years. This is that much russeting of the fruit may be due to natural causes and all of it should by no means be charged against the spray material. Mr. Bonns observed this in 1910 and commented on it in the first report of the series.†

In 1913 a large amount of russeting was observed, even on the unsprayed plot which showed over 31 per cent of the fruit so affected. In this connection it is interesting to note that russeting was actually less on the plot where 2 pounds of powdered lead arsenate was used than on the check. However on some of the other plots, particularly the one sprayed with bordeaux mixture it was very evident that the treatment applied, directly influenced the amount of injury obtained.

There is no doubt that the excessive amount of russeting which occurred the past season irrespective of the treatment was in some way associated with the climatic conditions which prevailed when the fruit was small. While there was an absence of the so-called "frost bands" on the fruit it is very probable that late frosts associated with heavy winds and cold rains were directly responsible for the trouble.

Arsenite of zinc with lime-sulphur. Very little comment is necessary with regard to the results obtained with this combination in 1913. In 1912 it was used with perfect safety on both foliage and fruit and was so reported. While practically no russeting of the fruit could be attributed to it in 1913, when compared with the check plot, the foliage injury already

* Headden, Wm. P., Arsenical Poisoning of Fruit Trees. Bul. Colo. Arg. Exp. Sta. 131, 1908.

† Bonns, W .W., Orchard Spraying Experiments. Bul. Me. Agl. Exp. Sta. 189, 1911.

described was sufficient to indicate that arsenite of zinc is an unsafe material to use with lime-sulphur in spraying apple orchards.

ADDITIONAL DATA REGARDING SOLUBLE SULPHUR COMPOUND.

In a letter addressed to the Director of this Station under the date of October 18 the General Manager of the Niagara Sprayer Company stated that he was very much surprised to learn that we had very unsatisfactory results with their Soluble Sulphur Compound, as the general results they were receiving from all over the United States were very favorable. He admitted that in the New England States more burning had been experienced than in other sections and attributed this to the peculiar climatic conditions of the season, but they were convinced that with one pound to 50 gallons of water with 2 1-2 pounds of arsenate of lead the results would be satisfactory. In their printed directions supplied to us at the beginning of the season it was recommended that 1 1-2 to 2 pounds of the material be used to 50 gallons, with no reference to arsenate of lead. In the experiments already described 2 pounds of Soluble Sulphur and one pound of dry arsenate of lead (approximately equivalent to 2 pounds of the paste form) were used.

Since our own report on the results obtained with this compound upon apple foliage must be an adverse one it seemed only just that an effort be made to determine whether or not this agreed with the experience of other users of the Soluble Sulphur Compound in Maine during 1913. Accordingly a circular letter was at once prepared, asking for information on this point, and sent to some over 100 orchardists in various parts of the State, mostly members of the Maine Pomological Society. Many of the replies received indicated that the general impression among the apple growers is that Soluble Sulphur Compound is simply a lime-sulphur concentrate with all of the water removed. Attention should be called to the fact that this is not the case and the Niagara Sprayer Company have never made such a claim in any of the literature which the writer has seen. In justice it should also be mentioned that nothing which is said here regarding the Soluble Sulphur Compound in any way

applies to the ordinary liquid lime-sulphur concentrate put out by the Niagara Sprayer Company. So far as this Station has tested the latter material it is fully equal to any on the market with reference to its effects on the foliage and efficiency in scab control.

Sixty-three replies to the circular letter were received, and only 11 of the writers said they had used the material in question in 1913. Farther correspondence developed the fact that one of these, who reported no burning of the foliage, did not use Soluble Sulphur Compound at all but the lime-sulphur concentrate put out by the same company. Another used Soluble Sulphur Compound only as a dormant spray. A third reported that his foliage looked sickly during the early part of the season whether sprayed or not.

One case was reported from Kent's Hill where the trees were thoroughly sprayed with 1 1-2 pounds of Soluble Sulphur Compound and 2 pounds of arsenate of lead in 50 gallons of water about 10 days after the petals fell and no injury resulted. Another case was reported to the writer, but not included in the replies to the circular letter, where the owner drenched the trees with this spray without injury. In neither of these cases were the names given of the varieties of apples sprayed, and in the last it was not stated how much Soluble Sulphur Compound was used and whether or not arsenate of lead was used with it.

One case was reported where slight burning of the leaves occurred with several varieties and four reports of severe foliage injury were received. One of these came from the same town where material was used successfully. The spraying was done on about the same date, the same amount of Soluble Sulphur Compound was used but 2 1-2 pounds instead of 2 pounds of arsenate of lead was added to each 50 gallons of spray. In this case the variety used was Baldwin and the owner reported that "It burned the foliage so seriously that much of it fell". Another report was as follows: "I will say, however, that it was very unsatisfactory in our hands. It has caused considerable injury and did not seem to be as effective as the solution of lime and sulphur". The third reported injury on Ben Davis but not on other varieties.

The most severe case of injury from Soluble Sulphur Compound and arsenate of lead reported came from Winthrop: "I used it to spray my apple orchard of about 3 acres on June 17, 1913. The varieties that were sprayed were Baldwin, Nodhead, Roxbury Russet, Winthrop Greening, Rhode Island Greening, Bellflower, Northern Spy and Canada Red. Half of the foliage and a great many apples fell. I used one pound of Soluble sulphur and 3 pounds of arsenate of lead to 50 gallons of water."

Mr. Geo. A. Yeaton, County Director of farm demonstration work for the University of Maine College of Agriculture in Oxford County used the material in an experimental way in some of his demonstration work and reported variable results. In one orchard the results were entirely satisfactory. In another orchard of 248 trees the foliage of Spy and Ben Davis trees was burned, while that on Baldwin and McIntosh showed no trace of it. Another orchard showed little or no burning. State Horticulturist, A. K. Gardner, stated he had used Soluble Sulphur Compound in a limited way and in each case there was a limited amount of spray injury, probably 10 per cent more than where the liquid (lime-sulphur) was used. "Other men have claimed that it burned their foliage and a few have said that it did not. The general consensus of opinion, however, has been that the liquid has proven more satisfactory." Mr. Gardner also reported the case mentioned above where the trees were drenched with the spray and did not suffer from any injury.

All reports received by the writer regarding Soluble Sulphur Compound as a dormant spray appear to be satisfactory. It is claimed by some that the injurious action on the foliage results from arsenic set free when combined with arsenate of lead. Doubtless this is the case, but no matter how efficient a fungicide may be it is impracticable to use it as a summer spray for apple trees unless some efficient insecticide may be combined with it and the two used at the same time without danger of leaf injury.

The Source of Spring Infection by Apple Scab.*

In this country it has been quite generally conceded that the early spring infection by apple scab comes entirely from the spores of the perfect stage of the causal fungus which have been produced on diseased leaves lying on the ground during the preceding winter. In fact all the previously accumulated evidence in America is in support of this position. In Europe certain writers have agreed with this while others maintained that scab infested twigs or young branches were also an important factor. It is generally agreed, however, that the scab fungus is at times parasitic upon young branches and water shoots and in this relation, particularly in the case of susceptible varieties, may be the source of considerable injury.

Conditions during the growing season in Maine in 1912 apparently were very favorable to the development of apple scab on the limbs. Early in the following winter specimens of young apple branches attacked by scab began to come to this Station from correspondents in various parts of the State. Since limb infection appeared to be so general it seemed that an excellent opportunity existed to determine whether or not the scab fungus would remain alive on these limbs over winter and become a source of infection the following spring. Accordingly Mr. W. H. Darrow, a graduate student working in the writer's laboratory, was assigned to this problem. Acknowledgment is made to him for much time spent examining local orchards, making spore germination tests, inoculation experiments and in collecting data on the relative susceptibility of varieties. Also thanks are due to State Horticulturist, A. K. Gardner, and Assistant State Horticulturist, H. P. Sweetser, of Augusta, as well as to Mr. George A. Yeaton and Mr. Arthur L. Deering, County Directors of farm demonstration work for the University of Maine College of Agriculture in Oxford and Kennebec Counties for furnishing us with material for study from various parts of the State.

* Morse W. J., and Darrow, W. H. Is Apple Scab on Young Shoots a Source of Spring Infection? Phytopathology 3: 265. Oct. 1913. The present discussion is a brief presentation of facts given in the previous article.

While the branches were frequently affected near the tip, in many cases the diseased area began one or 2 or even 3 inches back on last year's growth and extended back from one to several inches. The bark on the diseased portion of such branches was more or less thickly studded with light brown spots. Scattered spots were, as a rule, oval to elongate in shape, although frequently nearly circular, and were usually not much larger than a pin-head. Quite often in severe cases these spots ran together, forming a diseased patch of considerable area which appeared as a scurfy coating on the bark.

Closer examination of the light brown spots showed that they were blister-like pustules resulting from the death and pushing out of the epidermis or outer layer of the young bark. In the center of each pustule was a blackish portion composed of the olive-colored conidia or spores of the fungus.

A detailed study of the conditions in the field was made by Mr. Darrow in the vicinity of Orono. This was of necessity somewhat limited, as the location is outside of the best apple growing district of the state. It was observed that strong-growing water sprouts were more badly affected than young growth on the ends of branches. Water sprouts 2 or 3 feet long were often diseased for the last foot or more of their growth. Also the more vigorous growing twigs at the ends of the branches were the more severely attacked. Those which showed but little elongation were only slightly infested, or not at all.

In an orchard containing seven varieties, McIntosh and Fameuse were the worst attacked. Milden and Westfield ranked next in order of susceptibility. Only an occasional twig was found to be affected on the Northern Spy trees and these but slightly, while the Oldenburg and Tolman trees were entirely free from injury.

Many of the spores of the scab fungus, found in the pustules already mentioned, germinated readily when placed in proper culture media or even in water. These germinations were made at various times during the latter part of the winter and spring up to about the first of May. No exact data was secured to determine whether the spores so germinated were those formed the fall before or those which had been

produced in the early spring from the mycelium of the fungus which had remained alive in the diseased branches over winter. The latter might have been the case with some of the later germinations but under the climatic conditions which exist in this State it does not seem possible where the tests were made early in March.

Young apple trees growing in the greenhouse were inoculated by spraying the foliage with spores produced from cultures of the fungus obtained from diseased limbs. In a month or 6 weeks the leaves of these trees were badly attacked by apple scab. Scab did not develop on other young trees growing in the same greenhouse and which were not so inoculated.

From the above it would seem evident that in this climate it is perfectly possible for the apple scab fungus, and the conidia of the same, to live over winter on diseased twigs and water sprouts, and that this form of the disease may be an important factor in the production of early spring infection where susceptible varieties of trees are grown. In this connection it is a matter of extreme practical importance to know how effective a dormant spray of bordeaux mixture or lime-sulphur is in controlling this phase of the disease. In the laboratory it was found that simply dipping the affected twigs for a few seconds in the winter strength lime-sulphur sufficed to kill all living spores, but no results of a regularly conducted spraying experiment were secured. However, certain observations made by the writer furnish some rather interesting data upon this subject.

These observations were made upon a block of four-year-old McIntosh trees in an orchard belonging to Mr. F. H. Morse of Waterford. This consisted of 40 trees, 5 rows of 8 trees to the row, set on an acre of land. They had been well fertilized and cultivated, were 7 to 8 feet tall and were healthy and vigorous with the exception that several limbs on practically every tree had been attacked by scab the season before. Some of these were so severely injured as to kill them back for several inches. However, the badly attacked trees were by no means confined to any one part of the block. They were visited about the first of July.

It was the original plan of the owner to spray the trees before the buds opened with a dormant spray of lime-sulphur and again with the same material diluted to summer strength, just before the flower buds opened, and a third time after the petals fell. The first application was made about the first of May, using a 33° Beaumé concentrate, diluted 1 part to 10 of water. At this time the leaf buds on one row of 8 trees were slightly in advance of the rest and were just beginning to open. The owner fearing he would injure them omitted the application of the strong spray upon this row of trees. However, the remainder of the entire block received the dormant spray at this time, and all received the two later applications.

At the time the orchard was inspected, the leaves on the 32 trees to which all three applications of the spray were made were exceedingly healthy, although scab was not entirely controlled upon them. Those upon the 8 trees where the dormant spray was omitted showed a strikingly different condition. Fully 75 per cent were attacked by scab and a large proportion of these were quite severely affected. In fact only those of recent growth were free from the disease.

It is not the contention of the writer that spores of the perfect stage of the apple scab fungus, formed on the leaves of the previous year, are not the source of a great proportion, and usually all, of the early spring infection of apple scab. It is, however, maintained that, under certain conditions and with certain varieties of trees, diseased twigs and water sprouts are an important factor in the propagation and spread of the disease at the beginning of the following year. It would also seem from our observations that where limb infection exists the application of some strong fungicide immediately before the leaf buds open will greatly reduce the amount of spring infection from this source.

The European Apple Canker in Maine

In an earlier publication of this Station it was stated that while the European Apple Canker, caused by *Nectria ditissima* Tul., might be present in Maine it had not at that time been

observed.* Certain observations made during the past year by Mr. W. H. Darrow while working in this laboratory not only show that the fungus which is said to cause this disease is present in this State but that in some localities it occurs with considerable frequency. Several specimens identical in appearance with the descriptions and illustrations of canker said to be caused by *Nectria ditissima* were collected. These varied from small ones an inch or two in length to old ones 7 or 8 inches long. Figs. 3 and 4 show some of the specimens obtained.

In one young orchard they were found on the trunks of several trees while in older orchards the cankers appeared more abundant on branches an inch or two in diameter. Several of these cankers were found in crotches, suggesting that they might have followed winter injury. The larger part of them, however, showed the remains of a dead twig in the center indicating that the fungus may have gained entrance thereby.

The fruiting bodies of *Nectria ditissima* were quite constantly found on the older of these cankers and the ascospores found within these perithecia and the conidia produced in cultures agreed with the published descriptions of the fungus. This determination was confirmed by Dr. J. J. Davis of the University of Wisconsin who very kindly examined some of the material.

From cultures of the fungus isolated from some of the cankers Mr. Darrow made a limited number of inoculations of apple branches out of doors in May. These branches were about one-half inch through, and on this date, December 1, in all cases points of inoculation have every appearance of the beginning of a canker. The wounds, which were slight slits in the bark, have not healed but have enlarged—some of them covering from one-third to one-half the circumference of the limb. In one or two instances the limb itself was enlarged at the point of inoculation.

* Morse, W. J., and Lewis, C. E. Maine Apple Diseases. Bul. Me. Agr. Exp. Sta. 185: 371, 1910.

FIG. 1. Leaves injured by "Soluble Sulphur Compound" and arsenate of lead.

FIG. 2. Leaves injured by lime-sulphur and arsenite of zinc.

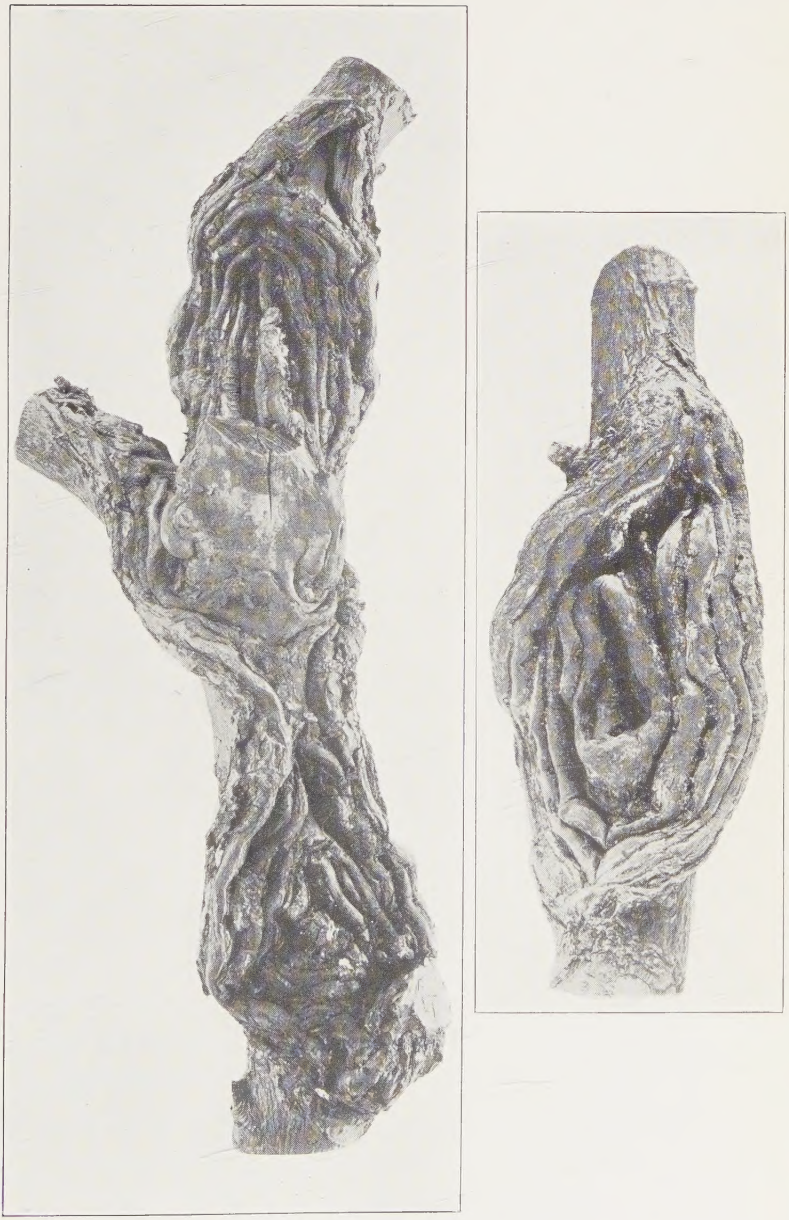

FIG. 3. European apple canker, advanced stages.

I. B.
E.

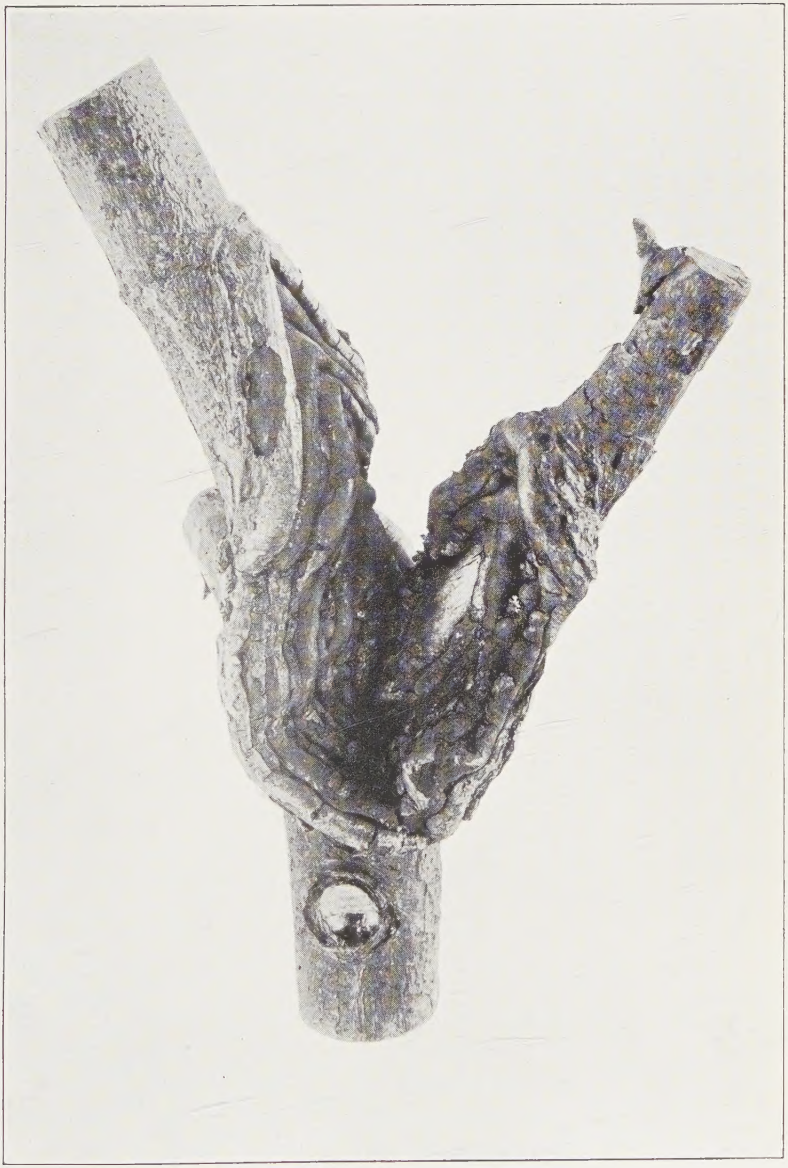

FIG. 4. European apple canker in crotch.

I.
I
I
I.
I.
B.
E.